

### **REMARKS**

This responds to the Office Action mailed on October 20, 2008.

No claims are amended, canceled, or added; as a result, claims 1 – 23 remain pending in this application. Applicant respectfully requests reconsideration and allowance of all claims in view of the following remarks.

#### **§102 Rejection of the Claims**

Claims 1-23 were rejected under 35 U.S.C. § 102(b) for anticipation by Quinn Able Jacobson (High-Performance Frontends for Trace Processors, 1999, University of Wisconsin – Madison)(hereinafter ‘Jacobson’ – art made of record). Applicant respectfully traverses these grounds of rejection for at least the reasons stated below.

Anticipation requires the disclosure in a single prior art reference of each element of the claim under consideration.<sup>1</sup> Applicant respectfully submits that the Office Action did not make out a *prima facie* case of anticipation. Jacobson does not teach or disclose each and every element of applicant’s claims because Jacobson does not describe *working sets*, instead Jacobson describes *traces*.

Jacobson discloses three microarchitectural mechanisms for trace processors which include (a) trace pre- construction, (b) instruction pre- processing, and (c) next-trace prediction. Jacobson states that “[a] trace is a valid dynamic sequence of instructions not longer than some maximum length (16 or 32 for example).”<sup>2</sup> Jacobson also states that “[t]races are formed by recording dynamic sequences of instructions observed in the processor.”<sup>3</sup> And Jacobson states that “[t]races are identifiable by their starting instruction and *the outcomes of branches within the trace*.”(emphasis added)<sup>4</sup> The traces described by Jacobson deal with branch outcomes and branch prediction. And, in particular, the trace is associated with a specific sequence of instructions

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<sup>1</sup> *In re Dillon* 919 F.2d 688, 16 USPQ2d 1897, 1908 (Fed. Cir. 1990) (en banc), cert. denied, 500 U.S. 904 (1991).

<sup>2</sup> See Jacobson P. 6 Lines 1 – 2.

<sup>3</sup> See Jacobson P. 23 Lines 13 – 14.

<sup>4</sup> See Jacobson P. 48 Lines 60 – 61.

In contrast, the present application presents “systems and methods to identify program working sets, detect working set changes and estimate working set sizes.”<sup>5</sup> A working set is not a trace as described by Jacobson. Applicant’s “working set” refers generally to “the regions of a program that are being actively used at any given time.”<sup>6</sup> In a working set, the specific instruction sequence is not considered. What is considered is merely whether instructions are executed or not.

**Claims 1 – 7.** Turning now to the claims, independent claim 1 recites an apparatus comprising instructions:

“...to instantiate a data structure in the memory to collect a representation of *a working set*; and  
defining a hash unit operable on the processing unit to map *a plurality of working set elements* into the data structure using a hash function.”

Applicant respectfully submits that Jacobson’s traces do not teach or disclose “a working set” or “a plurality of working set elements.” The term working set is specifically defined in the Applicant’s specification as follows:

“In a program, a working set  $W(t_i, \tau)$  for  $i=1,2,\dots$ , is a set of distinct memory segments  $\{s_1, s_2, \dots, s_\omega\}$  accessed over the  $i^{\text{th}}$  window of size  $\tau$ . . .”<sup>7</sup>

With regard to this definition, the applicant’s specification further states that “[t]he window is a sequence of  $\tau$  consecutive memory accesses. The working set size is  $\omega$ , the cardinality of the set of unique segments that are accessed by members of the window. In one example, the segments are memory regions of some fixed size, such as a page. In another example, the segments are memory regions of the size of a cache memory block.”<sup>8</sup> A cache memory block is also a fixed size region.

Jacobson fails to disclose every element of claim 1 for several reasons.

First, the Office Action points to section 5.2.1.1, Figure 5-3, section 5.3.1 and section 5.3.2 as disclosing the element of “to instantiate a data structure in the memory to collect a representation of *a working set*,” however, the Applicant can find no teaching of

<sup>5</sup> See Abstract of the present application.

<sup>6</sup> See Page 2 Lines 19 – 20 of the present application.

<sup>7</sup> See Page 3 Lines 5 – 6 of the present application.

<sup>8</sup> See Page 3 Lines 9 – 13 of the present application.

a working set in the cite passages. As stated above, Jacobson is directed to three microarchitectural mechanisms for trace processors. In particular, the sections of Jacobson's Chapter 5 that the Office Action relies on are directed to the next-trace prediction mechanism.

Regarding section 5.2.1.1, this section relates to control predictors which work "by observing how branches have behaved in the past to predict how they will behave in the future."<sup>9</sup> Section 5.2.1.1 describes hysteresis as one technique to increase the accuracy of the prediction. Hysteresis is implemented using a counter that is incremented when the prediction is correct and decremented when the prediction is not correct. However, section 5.2.1.1 does not disclose or teach "a data structure" to "collect a representation of a working set" as claimed in claim 1.

Regarding Figure 5-3, an example global history branch predictor is illustrated. As shown in Figure 5-3, a shift register stores the outcomes of the previous N branches which are used along with the PC of the current branch instruction to index a table of 2-bit counters and make a prediction.<sup>10</sup> The 2-bit counters "implement the functionality of encoding a prediction and one bit of hysteresis."<sup>11</sup> Thus, using the outcomes of the previous N branches (in sequence) may make any working set information indiscernable. Because the previous branch outcomes are used, the contents of the table indexed by the hash function will not be the same for multiple occurrences of the same working set. In fact, the same working set can yield a large number of different table contents (each depending on the outcomes of previous N branches). As a result, the 2-bit counters shown in Figure 5-3 are not a "representation of a working set" as claimed in claim 1.

Regarding sections 5.3.1 and 5.3.2, the office action does not identify the particular portion of these sections that are relied on to reject the claims. Both sections 5.3.1 and 5.3.2 describe next-trace predictors. However, sections 5.3.1 and 5.3.2 do not disclose or teach "a representation of a working set" as claimed in claim 1.

Thus, Jacobson does not disclose "to instantiate a data structure in the memory to collect a representation of *a working set*;" as claimed in independent claim 1. In fact the

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<sup>9</sup> See Jacobson Page 164 Lines 19 – 20.

<sup>10</sup> See Jacobson Page 167 Lines 18 – 20.

<sup>11</sup> See Jacobson Page 167 Lines 17 – 18.

mechanism described by Jacobson tends to obscure working set information because of the hash with the previous N branch outcomes.

Second, the Office Action points to Figures 5-3 and 5-5 as disclosing “defining a hash unit operable on the processing unit to map *a plurality of working set elements* into the data structure using a hash function;” however, the Applicant can find no teaching of a plurality of working set elements as claimed in claim 1. As noted above, Figure 5-3 illustrates an example global history branch predictor. In addition, Figure 5-5 illustrates the hashing function of a correlated predictor which works as follows:

“The hashing function uses the outcome of the first two conditional branches in the trace identifier as the least significant two bits, the two least significant bits of the starting PC as the next two bits, the upper bits are formed by taking the outcomes of additional conditional branch outcomes and exclusive-ORing them with the next least significant bits of the starting PC.”<sup>12</sup>

However, the hashing function shown in Figure 5-5 of Jacobson does not “map *a plurality of working set elements* into the data structure” as claimed in claim 1 because the table entries do not correspond directly to working set elements.

Third, the Office Action states that Jacobson discloses the following elements of claim 1:

“a processing unit of a processor;”

“a memory coupled to the processor;” and

“an instruction set operable on the processing unit of the processor. . .”

However, the Office Action fails to identify the particular part of Jacobson relied on for these elements. Applicant notes that the Jacobson reference is a 225 page dissertation for a PhD degree in electrical and computer engineering. Because the subject matter of the reference is complex and describes several different inventions, the Applicant respectfully requests that the next Office Action designate the particular part(s) of the Jacobson reference relied on for these three elements if this rejection is maintained.

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<sup>12</sup> See Jacobson Page 171 Lines 1 – 4.

Thus, Applicant respectfully submits that Jacobson does not teach every element of claim 1 because Jacobson does not disclose mapping working sets. Rather, Jacobson discloses traces. In addition, claims 2 – 7 depend, directly or indirectly, on claim 1 and are patentable over Jacobson for the reasons argued above, plus the elements in the claims.

**Claims 8 – 11.** Turning now to the next independent claim, claim 8 recites a method of creating a representation of a working set comprising:

“mapping a *plurality of working set elements* into fields of a data structure using a hash function.”

The Office Action again points to Figure 5-3, 5-5, section 5.2.1.1, section 5.3.1 and section 5.3.2 of Jacobson as disclosing the elements of claim 8. However, as stated above in the discussion of claim 1, Chapter 5 of Jacobson is directed to a next-trace prediction mechanism. The figures and sections cited in the Office Action describe methods of predicting what the next trace will be. However, the next trace prediction methods described in Jacobson do not teach “mapping a plurality of working set elements into fields of a data structure.” A “working set” as defined in the Applicant’s specification<sup>13</sup> is not a “trace” as described by Jacobson.

Thus, Applicant respectfully submits that Jacobson does not teach every element of claim 8 because Jacobson does not disclose working set elements. In addition, claims 9 – 11 depend, directly or indirectly, on claim 8 and are patentable over Jacobson for the reasons argued above, plus the elements in the claims.

**Claims 12.** Turning now to the next independent claim, claim 12 recites an alternative method of creating a representation of a working set comprising:

“executing a program for a fixed interval, the program comprising instructions identified by a program counter;  
performing a hash function on the program counter to create a hash value for each instruction executed during the fixed interval; and  
updating a field of a table indexed by the hash value wherein the table represents *the working set*.”

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<sup>13</sup> See Page 3 Lines 5 – 13 of the present application.

The Office Action again points to Figures 5-3 and 5-5 of Jacobson as disclosing the elements of claim 12. However, as stated in the discussions of claims 1 and 8, these figures show particular methods of predicting what the next trace will be. The next trace prediction methods described in Jacobson do not teach “updating a field of a table indexed by the hash value wherein the table represents *the working set*.” A “working set” as defined in the Applicant’s specification<sup>14</sup> is not a “trace” as described by Jacobson.

Thus, Applicant respectfully submits that Jacobson does not teach every element of claim 12 because Jacobson does not disclose working sets.

**Claims 13 – 14.** Turning now to the next independent claim, claim 13 recites a computer system comprising:

“a data structure to collect a representation of *a working set*; and  
a hash unit to map *a plurality of working set elements* into the data structure using a hash function.”

As in the rejections of claims 1 and 8, Office Action again points to Figure 5-3, 5-5, section 5.2.1.1, section 5.3.1 and section 5.3.2 of Jacobson as disclosing the elements of claim 8. However, as stated above in the discussion of claims 1 and 8, Chapter 5 of Jacobson is directed to a next-trace prediction mechanism. The figures and sections cited in the Office Action describe methods of predicting what the next trace will be. However, the next trace prediction methods described in Jacobson do not teach “working sets” or “a plurality of working set elements” as claimed in claim 13. A “working set” as defined in the Applicant’s specification<sup>15</sup> is not a “trace” as described by Jacobson.

In addition, the Office Action states that Jacobson discloses the following elements of claim 13:

“a bus;”  
“a memory coupled to the bus;” and  
“a processor coupled to the memory and the bus; . . .”

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<sup>14</sup> See Page 3 Lines 5 – 13 of the present application.

<sup>15</sup> See Page 3 Lines 5 – 13 of the present application.

However, the Office Action fails to identify the particular part of Jacobson relied on for these elements. Applicant again notes that the Jacobson reference is a 225 page dissertation for a PhD degree in electrical and computer engineering. Because the subject matter of the reference is complex and describes several different inventions, the Applicant respectfully requests that the next Office Action designate the particular part(s) of the Jacobson reference relied on for these three elements if this rejection is maintained.

Thus, Applicant respectfully submits that Jacobson does not teach every element of claim 13 because Jacobson does not disclose working sets. In addition, claim 14 depends directly on claim 13 and is patentable over Jacobson for the reasons argued above, plus the elements in the claim.

**Claims 15 – 16.** Turning now to the next independent claim, claim 15 recites a computerized method of estimating size of a working set comprising:

“Receiving a signature for a working set; and

Estimating the size of the working set based on the size of the signature.”

The Applicant’s specification specifically defines “working set signature” as “a highly compressed representation of the working set.”<sup>16</sup>

The Office Action points to Figure 5-3 of Jacobson as disclosing “receiving a signature for a working set.” However, as previously stated Figure 5-3 shows an example global history branch predictor. The 2-bit counters shown in Figure 5-3 “implement the functionality of encoding a prediction and one bit of hysteresis.”<sup>17</sup> The 2-bit counters shown in Figure 5-3 are not “receiving a signature for a working set” as claimed in claim 15.

The Office Action points to page 53 of Jacobson as disclosing “estimating the size of the working set based on the size of the signature.” This is part of Jacobson’s chapter 3 on trace pre-construction. Jacobson states that “pre-construction is implemented with a sophisticated mechanism that sequences ahead of the processor and generates likely future traces.”<sup>18</sup> The paragraph on page 53 of Jacobson relied on by the Office Action describes trace pre-construction based on dynamic learning. However, the trace

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<sup>16</sup> See Page 3 Line 30 to Page 4 Line 2 of the present application.

<sup>17</sup> See Jacobson Page 167 Lines 17 – 18.

<sup>18</sup> See Jacobson Page 47 Lines 3 - 5.

preconstruction methods described in Jacobson do not teach “estimating the size of the working set based on the size of the signature” as claimed in claim 15. A working set signature is a representation of a working set. A “working set” as defined in the Applicant’s specification<sup>19</sup> is not a “trace” as described by Jacobson.

Thus, Applicant respectfully submits that Jacobson does not teach every element of claim 15 because Jacobson does not disclose working sets or signatures for working sets. In addition, claim 16 depends directly on claim 15 and is patentable over Jacobson for the reasons argued above, plus the elements in the claim.

**Claims 17 – 18.** Turning now to the next independent claim, claim 17 recites a method of detecting working set changes comprising:

“comparing *a current working set signature* to a previous working set signature;

calculating *a relative signature distance* between the current working set signature and the previous working set signature; and

identify *a working set change* when the relative signature distance exceeds a predetermined threshold.”

The Office Action points to pages 16 and 61 of Jacobson as disclosing the elements of claim 17. The discussion on page 61 is part of Jacobson’s chapter 3 on trace pre-construction and the discussion on page 16 is part of an introductory section on next trace prediction. Neither of the discussions describes working set signatures as claimed in claim 17. A working set signature is a representation of a working set.<sup>20</sup> A “working set” as defined in the Applicant’s specification<sup>21</sup> is not a “trace” as described by Jacobson.

Applicant respectfully submits that Jacobson’s traces do not teach or disclose “a current working set signature,” “a relative signature distance,” or “a working set change.”

Thus, Applicant respectfully submits that Jacobson does not teach every element of claim 17 because Jacobson does not disclose working set signatures. In addition,

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<sup>19</sup> See Page 3 Lines 5 – 13 of the present application.

<sup>20</sup> See Page 3 Line 30 to Page 4 Line 2 of the present application.

<sup>21</sup> See Page 3 Lines 5 – 13 of the present application.



claim 18 depends on claim 17 and is patentable over Jacobson for the reasons argued above, plus the elements in the claims.

**Claims 19 – 21.** Turning now to the next independent claim, claim 19 recites a method of identifying a recurring working set comprising:

“comparing *a current working set signature to one or more previous working set signatures*;

calculating *a relative signature distance* between the current working set signature and the one or more previous working set signatures; and

identifying *a recurring working set* when the relative signature distance between the current working set signature and one of the previous working set signatures is within a predetermined threshold.”

Again, the Office Action points to pages 16 and 61 of Jacobson as disclosing the elements of claim 17. The discussion on page 61 is part of Jacobson’s chapter 3 on trace pre-construction and the discussion on page 16 is part of an introductory section on next trace prediction. Neither of the discussions describes working set signatures claimed in claim 17. A working set signature is a representation of a working set.<sup>22</sup> A “working set” as defined in the Applicant’s specification<sup>23</sup> is not a “trace” as described by Jacobson.

Applicant respectfully submits that Jacobson’s traces do not teach or disclose “a current working set signature,” “a relative signature distance,” or “a recurring working set.” Thus, Applicant respectfully submits that Jacobson does not teach every element of claim 19. In addition, claims 20 – 21 depend, directly or indirectly, on claim 19 and are patentable over Jacobson for the reasons argued above, plus the elements in the claims.

**Claims 22 – 23.** Turning now to the next independent claim, claim 22 recites a hardware configuration method comprising:

“maintaining a table comprising *a plurality of working set signatures* for a program;

upon detecting *a working set change*, looking up *a working set signature for a current working set* in the table;

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<sup>22</sup> See Page 3 Line 30 to Page 4 Line 2 of the present application.

<sup>23</sup> See Page 3 Lines 5 – 13 of the present application.

if the working set signature is in the table, reinstating a hardware configuration for the current working set; and

if the working set signature is not in the table; identifying a new hardware configuration for the current working set and saving the working set signature and the new hardware configuration.”

The Office Action again points to Figure 5-3, section 5.2.1.1, section 5.3.1, section 5.3.2 and page 16 of Jacobson as disclosing the elements of claim 22. However, as stated above in the discussion of claim 1, Chapter 5 of Jacobson is directed to a next-trace prediction mechanism. The figures and sections cited in the Office Action describe methods of predicting what the next trace will be. However, the next trace prediction methods described in Jacobson do not teach do not disclose “a plurality of working set signatures,” “a working set change,” or “a working set signature for a current working set.” A working set signature is a representation of a working set.<sup>24</sup> A “working set” as defined in the Applicant’s specification<sup>25</sup> is not a “trace” as described by Jacobson.

Thus, Applicant respectfully submits that Jacobson does not teach every element of claim 22. In addition, claim 23 depends on claim 22 and is patentable over Jacobson for the reasons argued above, plus the elements in the claims.

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<sup>24</sup> See Page 3 Line 30 to Page 4 Line 2 of the present application.

<sup>25</sup> See Page 3 Lines 5 – 13 of the present application.

**CONCLUSION**

Applicant respectfully submits that claims 1 - 23 are in condition for allowance, and notification to that effect is earnestly requested. The Examiner is invited to telephone Applicant's representative at (612) 349-9592 to facilitate prosecution of this application.

If necessary, please charge any additional fees or credit overpayment to Deposit Account No. 19-0743.

Respectfully submitted,

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Date March 20, 2009

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CERTIFICATE UNDER 37 CFR 1.8: The undersigned hereby certifies that this correspondence is being filed using the USPTO's electronic filing system EFS-Web, and is addressed to: Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on this 20<sup>th</sup> day of March, 2009.

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